IRIS: A stratospheric water isotope ratio spectrometer based on optical-feedback cavity enhanced absorption

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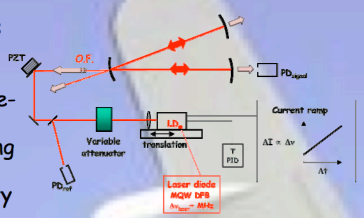
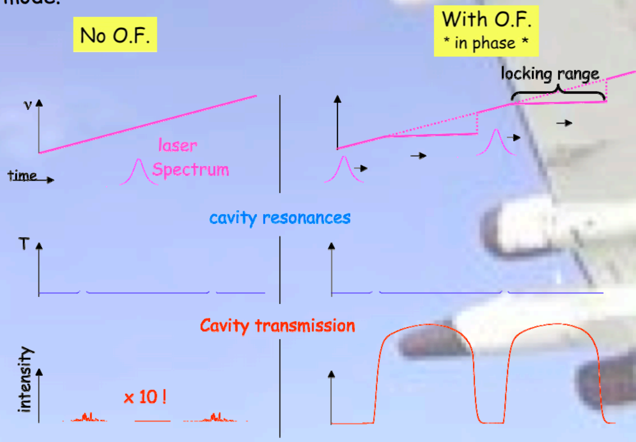
Brief project history:
1999: Dutch NSF grant for whole air, cryogenic sampling project
2001: Proposal redefined: *in-situ*, spectroscopic detection
- Increased temporal and thus spatial coverage
- No need for cryogens
- Reduce chance of sampling related (systematic) errors

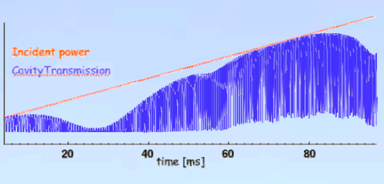
2003/1: PhD (RI) started, collaboration with Grenoble initiated
2003/7: Assured access to NASA DC-8 (HJJ)
2004/6: First successful DC-8 test flights at Dryden
2005/6: Second generation device for stratospheric flights

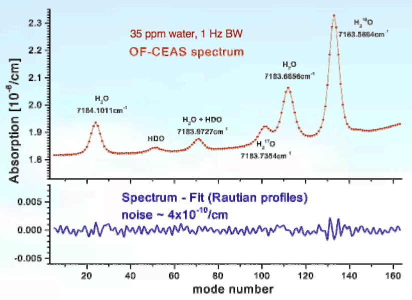
OF-CEAS (Grenoble patent):
Drastically increased light injection into high-finesse (F~10^4) optical cavity by phase-controlled optical feedback, resulting in linewidth narrowing and self-locking of the laser frequency to the narrow cavity mode.



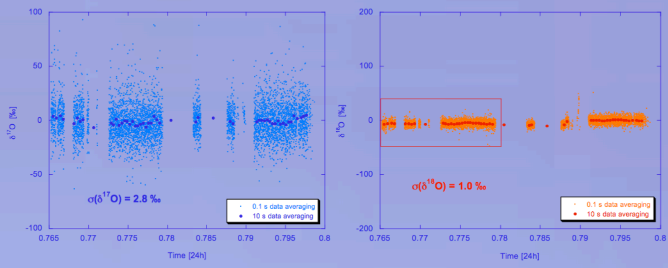


The absorption lines are superimposed on the cavity transmissions and appear enhanced as if observed as the output of a multiple-pass cell with an effective length given by ~$F \cdot L$, of the order of 10 km. The spectrum is recorded cavity mode-by-cavity mode, separated by the cavity FSR (~150 MHz), such that noise on the frequency scale is completely negligible.

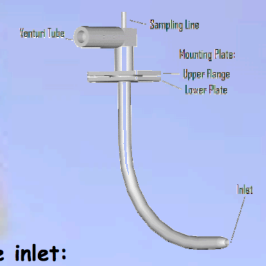




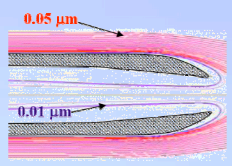
DC-8 device performance:
Assuming constant water vapor conditions during level flight, precisions are 9‰ for δ^2H, 3‰ for $\delta^{17}O$, and 1‰ for $\delta^{18}O$ (10 s averaged data, ~200 ppm).

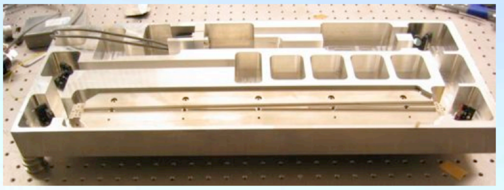


Second generation device:
Shot noise limited detectors, better laser (power, tuning), reduced sensitivity to acoustic noise, autonomous operation with PC104 computer, higher flow rate (cell refreshed ~10 s^{-1}), vapor phase only inlet



Vapor phase inlet:
Designed for particle-cut-off at 10 nm and no wall contact.
- shaped backward facing inlet
- sub-sampling near instrument





Technical specifications:
Optical head ~70x35x18 cm^3, PC ~13x16x21 cm^3.
Total weight (include. Pump and inlet) ~ 45 kg.
Power consumption 175 W typical, 280 W max.

Acknowledgements:
Indispensable technical support by Henk Been, Samir Kassi, Bruce Borchers, Jim Terman, Jimena Lopez, Ric Kolyer, Rene Castaneda
Funding from Dutch Foundation for Research on Matter (FOM), University of Groningen, Royal Netherlands Academy of Sciences (KNAW), NASA